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Original Research Paper

Assessment of Flood Disaster Vulnerability for Flood Insurance Programme in Part of Makurdi Floodplain, Benue State, Nigeria

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Flood is one of the most devastating natural hazards in the world. A floodplain is primarily a river sediment, populated, rich with fertile soils, but is subjected to flooding. This study focuses on the flood risk vulnerability of residential areas on parts of the Makurdi urban area with flood insurance programme as a pre-flood disaster measure. The study utilized a remotely sensed data of the area, processed it and produced a topographic map and digital elevation model. An overlay was done to produce the level of flood risk vulnerability for the residential areas as well as the catchment areas. The result shows that the highest catchment area of 22.01% lies within the moderate risk zone affecting Gaadi, Wurukum and Logo while the least of 4.15% is for the low risk zone affecting part of Lobi. The study recommends a comprehensive mapping and publication of the Nigeria floodplain to determine the 100-year flood zones for risk status as well as land use planning and management.

Keywords: Floodplain, flood, floodplain map, flood insurance programme, 100-year flood zone.

INTRODUCTION

Flood is among the most devastating natural hazards in the world, claiming lives and properties more than any other natural phenomena (Ologunorisa, 2001). Flooding occurs when natural or man-made water bodies cannot sufficiently transport or hold excess water generated by storms or other sources, thereby overflowing their normal beds to flood the nearby lands.

The lands adjacent to these bodies of water, as well as low-lying areas that cannot transport excess rainfall are called flood plains. A flood plain is primarily of river sediment and is subject to flooding (Glimer, 1995). Development often occurs in the floodplain because of the rich, fertile soils that occurs there. According to Glimer (1995), as the population in floodplains increases, so is the damage caused by flooding. Damage in floodplain resulting from flooding can range from water inundating a basement to the complete loss of a structure. Also, sewers and septic systems can rupture or overflow during a flood event, causing contamination of rivers, stream and groundwater. The effect of floods can be felt at the local level, affecting communities and neighbourhoods, or at regional or national levels, affecting entire drainage basins and large sparse of land between states (Kwak and Kondoh, 2008). A variety of climate and non-climatic processes influence flood processes, resulting to river floods, flash floods, urban floods, coastal floods, etc. (Ojigi, Abdulkadir and Aderogu 2013).

Mitigation of flood disaster can be successful only when detailed knowledge is obtained about the vulnerability of the people, buildings, infrastructure and economic activities in a

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potentially dangerous area (Van Western and Hosfstee, 2000). In the view of Ishaya, Ifatimehin and Abaje, 2009), one way to mitigate the effects of flooding is to ensure that all areas that are vulnerable are identified and adequate precautionary measures taken to ensure adequate preparedness, effective response, quick recovery and effective prevention. One fundamental way of identifying vulnerability is to obtain information on vital indices of flood risk identification, which includes elevation, among others (Ishaya *et al,* 2009).

The Nigerian government established the National Emergency Management Agency (NEMA) with the task of formulating policies, assessment of natural and man-made disasters, provision of mitigating measures for disaster-related activities, coordinating plans and programmes for offering relief to victims of such disasters (NEMA 2011).

The US National Flood Insurance Programme was created in 1968 by the US Congress in response to the rising cost of disaster relief for flood victims (Mathews, 2011). The national flood insurance programme as enunciated by the National Academy of Sciences (2007) is designed to provide an alternative to NEMA assistance to reduce the costs of repairing damage to buildings and their contents caused by flooding. The insurance is also required in order for property owners in flood plains to get mortgages. In addition, the insurance will encourage communities to regulate the land development in their flood plains to avoid flood damages, and in return allow property owners located in flood hazard areas to purchase the insurance.

Most of the information on flood risk identification indices is geospatial in nature and therefore requires geospatial information collection and analysis. To be effective, any flood plain management strategy or programme requires topographic data, even in the determination of the nature of flood hazard or flood risk mapping. Geographical Information Systems (GIS) is one of such effective and efficient tools (Jayasselan 2006). GIS applications in flood risk mapping range from collecting, storing and managing data, to generating flood and hazard maps to assist flood risk management. GIS technology has gained popularity over the last decade in flood risk assessment, modelling and mapping (Ishaya *et al*, 2009; Nwilo, Olayinka, and Adzandeh, 2012; Ojigi *et al*, 2013).

STATEMENT OF THE PROBLEM

Government response to floods in Nigeria has been instantaneous. The Nigerian meteorological agency (NIMET) did predict floods long before they came. Because floods are an intrinsic part of the hydrologic cycle and are specifically linked to the high incidences of rainfall and a variety of ubiquitous factors that influence flood processes, there is a need for a more sustainable approach than this fire-brigade approach by NEMA, which seem to lack the desired capability in managing the various disasters that have occurred in Nigeria in recent years. This equally calls to question the level of disaster response in the country.

The challenges of inadequate trained personnel, and inappropriate technology to effectively handle the dynamics of flood disasters, call for the need for a geospatial technology to guide the production of floodplain maps for integration into a national flood insurance programme. This is a pre-flood disaster programme as against the fire-brigade post-disaster approach usually employed by Nigerian government.

FLOODPLAIN MAPS AND FLOOD INSURANCE PROGRAMME

The creation of floodplain maps is a fundamental part of a national flood insurance programme. Floodplain maps define flood hazard zones, and the level of flood risk varies depending on location. They also determine whether flood insurance is required for homes or buildings located in the flood zones. The two framework layers of flood plain maps are the base map (planimety or 2-D) and the topographic map (3-D). The base map shows the spatial extent of the floodplain, providing spatial location of infrastructure or structures on the land surface. The topographic map shows the elevation data, i.e. the topographic nature of the terrain. Topographical information is important in defining the direction, velocity and depth of flood flows, as well as the structures at risk based on the 3-D criteria.

In support of the insurance programme, the flood plain maps should show the Base Flood Elevation (BFE), defined as the water surface elevation that would result from a flood having a percent chance of being equalled or exceeded in any year at the mapped location. The BFE is more commonly known as the "100-year flood level". In relation to BFE, the U.S. Executive Order No. 11988 (1977) defines flood plains as "lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands, including at a minimum, that area subject to a one percent or greater chance of flooding in any given year" (i.e. the area inundated by a 100-year flood). In the U.S, the 100-year flood has been adopted by the Federal Emergency Management Agency (FEMA) as the base flood for floodplain management purposes, as well as uses the 500-year flood (i.e. a 0.2 percent annual chance of occurrence) to indicate additional areas of flood risk (Landrum and Brown Team, 2008).

The Executive Order No. 11988 requires federal agencies to determine whether a proposed action will occur in a floodplain and, if the encroachment is significant, determine if the proposed action is the only practicable alternative before proceeding. However, if the agency finds out that the only practicable alternative requires siting in a floodplain, the order requires that the proposed action be designed or modified to reduce adverse floodplain impacts.

THE STUDY AREA

Makurdi town is the capital of Benue State and lies between latitudes $7^0 37^1$ and $7^0 17^1$N and longitudes $8^0 37^1$ and $8^0 40^1$E. According to the 2006 population census, Makurdi Local Government Area has a population of 300, 377 people, but has shown a considerable increase since then, especially with the influx of people from troubled neighbouring states and beyond. The nature of land-use in the area varies from administrative, residential, educational, recreational, industrial, urban agriculture, settlement, transportation to commercial uses, and covers all kinds of human activities on land (Lyam, 1995).

Makurdi town is situated on the plains of River Benue that separates the town into two – the North Bank and southern part. The River Benue plains have hydrometric soils found in the fadama plains with alluvial soils in the stream channels (Denga 1995). These largely explain why farming and fishing thrive in the area. The area belongs to the tropical wet dry (Kopen's Aw) climatic classification and due to the enclosure of the town in the Benue valley, the microclimate is greatly

influenced by high temperature, especially in the months of March and April.

Makurdi town lies within the guinea savannah belt with different species of trees, shrubs and grasses that have disappeared as a result of urbanization. This has left most land surfaces bare, thus resulting in an accelerated rate of flooding in the area.

According to Tyubee (2009) Makurdi lies within the zone of the Benue valley where the floodplain elevation generally averages 250m above sea level, but rises to 450m above sea level towards the hinterlands in the high plains. However, locally, its relief can be divided into 2, i.e. the high plain areas, which include the high level and North Bank, and are characteristically prone to erosion. The second is the floodplains which include Wurukum, Wadata, Logo, Akpehe, Idye, Gyado Villa and Modern Market areas. Those make up the southern part of the town and are seasonally affected by floods when River Benue is in its highest volume and overflows its banks. The town does not have a good drainage mainly due to its low-lying nature and geology that creates water-logging in several areas.

METHODOLOGY

The following procedures were involved in this study – data acquisition, georeferencing (using the spatial georeferencing tool of ArcGIS 10.2 application software), projection and transformation (WGS 84, Zone 32N), data extraction, contour interpolation and contouring, and Digital Elevation Model creation.

DATA ANALYSIS AND RESULTS

See Fig. 1

SPATIAL ANALYSIS TECHNIQUES

The contour, spot heights and DEM aspects were employed to compute the inundated (catchment) areas, and the classification of levels of flood risk vulnerability. The DEM aspect of the study area shows the height variations in 3D, indicating areas of high flood vulnerability, areas susceptible to flash flood during raining season, and areas susceptible to inundation.

The vulnerability of flood disaster occurrence is higher in the areas of interface between the water body and the upland areas especially areas of close proximity to the floodplain. In general, water overflows its banks to these areas during the peak of rainfall seasonally as well as the pool of surface run-off from the surrounding areas of higher elevations. The result of the analysis is shown in Table 1.

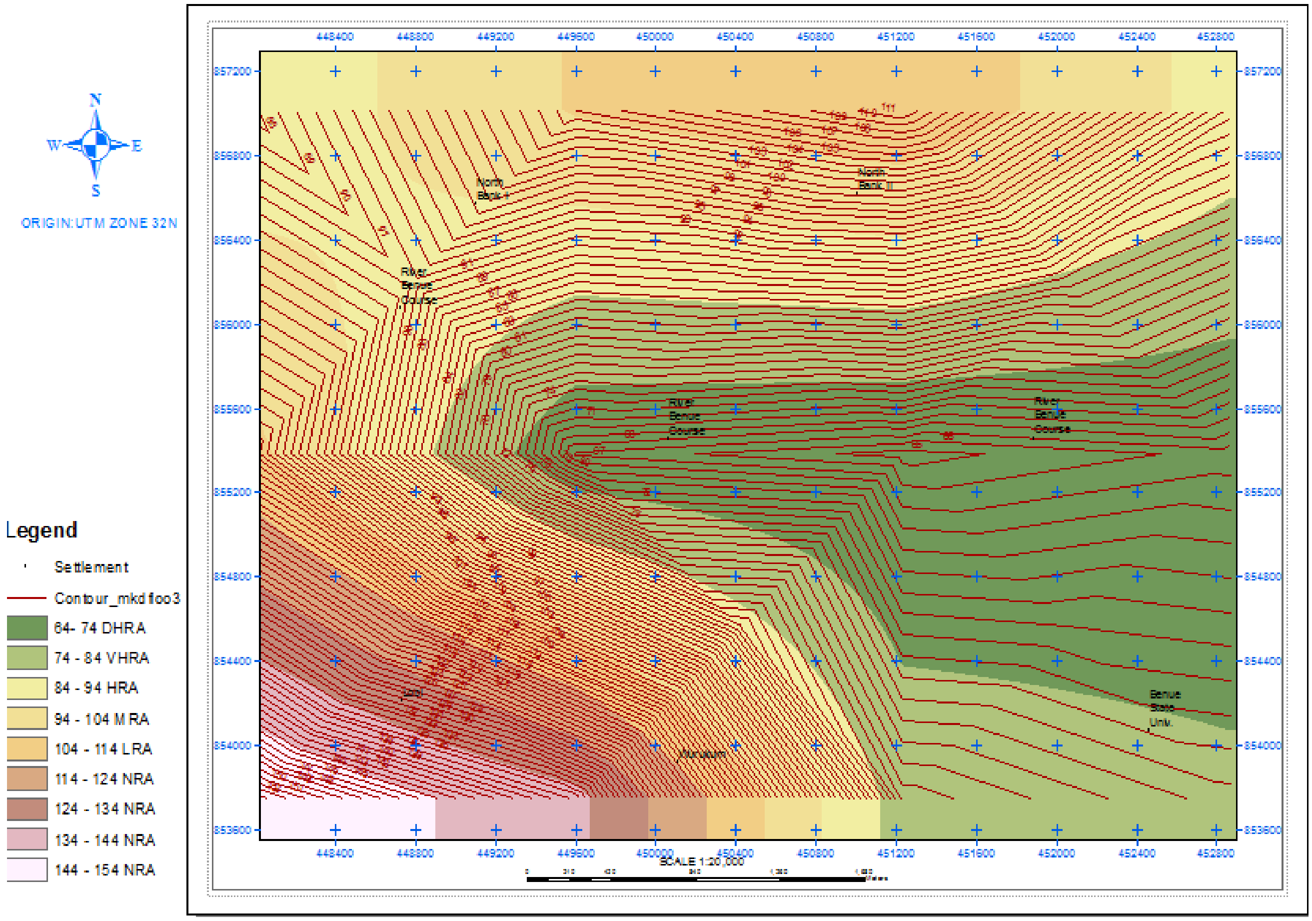

Fig.1 Overlay of DEM, Contours and Spot heights map of the study area

Table 1: Level of flood risk vulnerability for residential Areas and Catchment Areas

S/N	Level of vulnerability	Residential Areas	Catchment Area	% of area
1	Dangerously high risk zone (64-74 m)	River Bank & Course	534.95 hectares	16.75%
2	Very high risk zone (74-84m)	BSU & Environs	621.89 hectares	19.47%
3	High risk zone (84-94m)	Part of North Bank I, Logo	670.25 hectares	20.99%
4	Moderate risk zone (94-104m)	Part of Gaadi, Wurukum, Logo	702.87 hectares	22.01%
5	Low risk zone (104-114m)	Part of Lobi	132.68 hectares	4.15%
6	No risk zone (114-154mL)	Part of Lobi,	531.14 hectares	16.63%
	TOTAL		**3,193.77 Ha**	**100%**

Table 1 shows floodplain areas that can be inundated by 100-year flood based on the heights obtained above mean sea level (AMSL). From the table, a total of 3193.77 hectares of 100-year flood zone have been mapped and has revealed the various levels of vulnerability to flooding in the area. The highest catchment area of 22.01% lies within the moderate risk zone, and serves as the ecological footprint for the following residential areas – part of Gaadi, Wurukum and Logo. The least of 4.15% is for the low risk zone housing part of Lobi.

The data in Table 1 can be used to create flood insurance programme (FIP) map that delineates areas determined to have a 1% chance of flood in a given year (100-year floodplain). Within the FIP, flood risk policy and premium rates are to be based on consideration of vulnerability status and the risks involved. The programme enables property owners in participating communities or residential areas to purchase insurance protection against losses from flooding, hence reducing the demand for and reliance on post-disaster assistance.

CONCLUSION

The US flood insurance programme was created in response to the rising cost of disaster relief for flood victims, and has helped Americans recover from devastating floods for over 4 decades. By ensuring that floodplain maps and insurance rates reflect flood risk, Nigeria can save lives, properties and money. This makes sense today as climate change brings more severe floods, and becoming flood smart means knowing your vulnerability status and being insured.

RECOMMENDATIONS

In view of the challenges posed to sustainable development in Nigeria by flood disasters, it is therefore recommended that:

i. A comprehensive floodplain mapping of the floodplains of the Makurdi urban area be undertaken and published to determine the 100-year flood zones, as well as for land-use planning and management.
ii. A comprehensive pro-disaster programme such as a flood insurance programme be put in place as against post-disaster approach being practiced in Nigeria, particularly in the area.
iii. The floodplain maps should be used in the structural design of drainages and other flood preventive measures, especially in Benue State University and environs that are at very high risk.
iv. There should be adequate sensitization and education of the residents' vulnerability status as an environmental factor for residential and/or commercial preferences.

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